The Research on Optimal Control of Hvac Refrigeration System

He Bingqiang[1], Liao Chunling[2]

[1]Guangdong Jidian Polytechnic

Abstract

This paper gives a kind of optimal control method for HVAC refrigeration system. Controlling the frequency of compressor based on the suction pressure as control variable. Calculating the optimal suction pressure of various loads on principle of BP neural network model, so that make the refrigeration system obtain optimal state.

Keywords: *Refrigeration System; Optimal Control; Suction Pressure; BP Neural Network Model; Variable Load*

1. Introduction

With the development of productive forces and the improvement of living standards of the people, HVAC (HVAC) systems in China have been widely used in the HVAC technology and also gain great development in the vast majority of China's HVAC system in inefficient running state, resulting in low operating efficiency, a serious waste of energy [1] to solve the problem of energy wastage of HVAC systems is of great practical significance.

HVAC systems, chiller system occupy part of the cooling capacity and output, energy consumption accounts for about 50% of the entire HVAC system [2]. Refrigerator control method is good or bad directly affects the health of the entire HVAC system, the working status of the refrigerator as an important way of optimal control is the solution to the HVAC system energy consumption.

Many scholars approve of optimal control [3] [4], optimal control of the refrigerator, made a great contribution to the status of the chiller part load. But there are some problems, such as: a lot of people object refrigerator mathematical model [5], according to some of the state when the work of the refrigerator, the ideal assumptions and simplified mechanism model of refrigerator these assumptions and simplifications in practice are not established. Sometimes not on the choice of control variables is very reasonable, such as the use of chilled water supply temperature of the compressor operating frequency control variables [6] when the compressor changes state, the chilled water supply temperature because its operating characteristics cannot be timely changed.

BP neural network model of the actual operation data of the HVAC system is to identify the suction pressure, a variety of load conditions, which possess the guiding significance for the optimization of the entire HVAC system control.

2. Chiller Optimization Control Method

Optimal control of the refrigerator, the compressor operating frequency is an important issue. Suction pressure is an important parameter in the refrigerator and a measure of the refrigerator is functioning properly, the selection of the suction pressure is the compressor operating frequency of the control variables, such as control variables is more accurate than the temperature. However, due to the parameters, affecting the suction pressure has strong nonlinear characteristics; it is not easy to build a model of the mechanism. Based on actual data when the refrigerator is running, the suction pressures of BP neural network identification model, it is necessary to eliminate the impact of factors such as non-linear results.

In recent years, the inverter multi air conditioning (For simplicity, the following part of the place referred to as the MIAC) devices have excellent capacity control capability, excellent performance and low cost, energy saving, and application flexibility of a machine, and can effectively reduce the equipment space installation requirements, and many other advantages, have been widely used in small and medium-sized air conditioning works and the renovation and expansion project. International research in the field of focus in the compressor speed control, the dynamic performance of the components of the refrigerant distribution and electronic expansion valve (EEV) [1] [3].

As a new generation of building energy analysis software, the EnergyPlus inherited the classic

building energy consumption analysis software DOE-2 and BLAST advantage, while the development of many new features, which uses the integrated load - Equipment - system synchronization simulation method, easy maintenance Fortran90 modular development structure, and in some functional connection with other software such as SPARK and TRNSYS.

EnergyPlus HVAC system simulation can be achieved, including cold and heat source side equipment such as absorpt chillers, electric refrigerator, gas turbine chillers, boilers, cooling towers and other equipment as well as the end of the side fan coil units, VAV air box, and induction blower and so on. These devices were used in cold water, hot water and cooling water circuits connected together. Device simulation using the performance curve fitting, to add other types of modules [4] according to their needs. However, the current performance of the inverter multi air conditioning in the EnergyPlus simulation has not yet been achieved. Although domestic scholars also began to do some simulation of inverter multi air conditioning, its main purpose is to create a system of thermokinetic model to analyze the multi-linked system performance characteristics and test control algorithms. Combination of building energy consumption, and inverter multi air conditioning simulation studies have not been seen in the literature.

For the evaluation of this paper collected from the manufacturers of inverter multi air-conditioned samples and the limited publicly available data, the existing universal energy simulation software EnergyPlus energy and load performance of the inverter multi air conditioners. On the basis of the simulation software, the calculation module is developed. A typical example on the basis of analysis of the inverter multi-system part load performance characteristics, and results are validated with experiments in the literature [5]. This work is aimed at integrated building and HVAC system integration using EnergyPlus software energy simulation capabilities to assess the level of energy loss inverter multi associated air-conditioning systems and other HVAC equipment configuration scheme in practice.

1 inverter multi air conditioning energy consumption simulation module

Which is used to describe the performance curve of the air conditioning and refrigeration conditions EnergyPlus in a total of five: the temperature curve of cooling capacity, cooling capacity and air flow changes curve; energy input ratio (EIR) and the temperature curve, the energy input ratio (EIR) relationship with changes in air flow curve; and part of the load factor curve. The inverter multi air conditioning system's air supply air flow can be regarded as constant, so the flow curve can be omitted to use the performance curve three.

First, you need to add the data and read the program parameter input form of the inverter multi air conditioning equipment, in order to obtain the performance parameters of the inverter multi air conditioning; then the use of loading powerful software simulation main program and equipment integration simulation operation, the last data output management program that comes with the program output inverter multi air conditioning energy consumption calculated values.

After this transformation process, it can be adopted in the EnergyPlus software environment, the use of the powerful features of its construction and equipment simulation, the inverter multi air conditioning unit energy consumption simulation [5-10].

2.1.Suction pressure of the BP neural network model.

Inspiratory pressure output of the neural network, selects a close relationship with the suction pressure compressor inlet refrigerant temperature, the compressor outlet refrigerant temperature and load as the input variables of the neural network. According to the actual situation of the research object, the model of a hidden layer of five hidden layer nodes 3-5-1 mode identifies the suction pressure [11].

The data of the sample under different conditions are worthwhile by changing the input variables. Entering the 1500 actual measured input variable sample data and expectations of the suction pressure output value are calculated. BP algorithm the error goal = 0.01, learning rate lr = 0.01, the transfer function of hidden layer the tansig, the output layer transfer function purelin learning function learnbp. Calculated weights as follows:

To test the accuracy of the BP neural network model, with 50 sample data prepared in advance to predict the horizontal axis represents the 50 examples, and compared with the actual values, as shown in Figure 1. The results show that the forecast and actual values coincide, the description of the BP neural network model is accurate, and it is feasible in practice [12-15].

Table 1 suction pressure neural network model input layer and hidden layer weight table

Hidden layer nodes / Input nodes	1	2	3	4	5
1	0.9501	0.2317	1.5131	0.4858	0.8912
2	0.7621	0.4470	-0.1721	0.8212	0.4443
3	0.6154	0.7936	0.9248	0.7382	1.1763

Table 2 suction PRESSURES neural network model of the hidden layer and output layer weight table

Hidden layer nodes / Output node	1	2	3	4	5
1	0.1734	0.6984	0.6957	0.1779	0.6613

According to the suction pressure of the BP neural network model through computer simulation, observe the suction pressure in a certain load and compressor inlet temperature of the refrigerant. The figure is 100 percent load, 80% and 40% of the suction pressure of refrigerant with the compressor inlet temperature and compressor outlet refrigerant temperature. It can be observed that the maximum compressor inlet refrigerant temperature is higher than the value of the suction pressure, compressor outlet refrigerant temperature is lower, the value of the suction pressure is smaller, suction pressure of the compressor inlet refrigerant temperature reaches the highest, and compressor outlet refrigerant temperature reaches the minimum. In each load, the maximum suction pressure is unique [16].

2.2The best conditions of the refrigerator.

The COP of the chiller performance parameters measures the parameters of the chiller efficiency. Refrigerator runs when the refrigerant compressor inlet temperature, the compressor outlet refrigerant temperature and suction pressure value are defined as the conditions of the refrigerator. In the same load, the chiller conditions are numerous species, can be seen through the calculation of COP values that, under different operating conditions, the refrigerator's power is different. A certain load, the COP maximum conditions exist an optimum operating condition for the refrigerator, under the conditions to achieve the same cooling capacity, the best conditions is refrigerator energy consumption reaches minimum [17-19].

When the condensing pressure is constant, the increase in inspiratory pressure rise causes the refrigerant unit cooling capacity increases; reduced compressor suction specific volume of refrigerant vapor, and the improvement of the suction pressure, compressed by the refrigeration theoretical analysis shows that machine pressure ratio decreases, the volumetric efficiency increases, the quality of the actual inspirator increases and the cooling capacity of the compressor increases. Therefore the greater the suction pressure, suction pressure BP neural network model simulation can be different loads and have a maximum suction pressure, suction pressure of the load under optimal conditions , which corresponds to the compressor inlet temperature of the refrigerant, the compressor outlet refrigerant temperature, the value of their best condition [20].

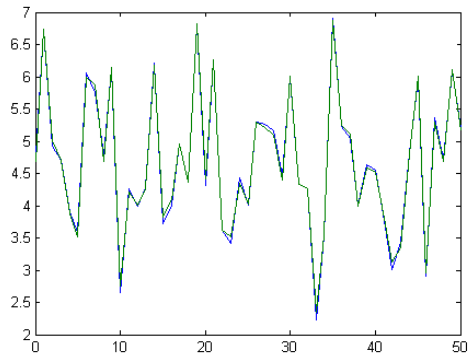

Figure 1 Test of instance

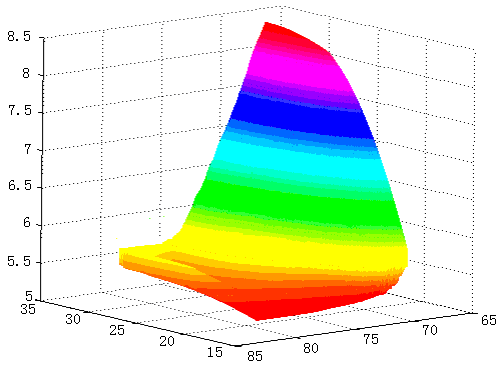

Figure 2 100% load nowadays variable relationship

The above analysis shows that under different loads and improve the work efficiency of the refrigerator in the larger state of the suction pressure in the compressor inlet temperature of the refrigerant, the compressor outlet refrigerant temperature to achieve

the best the value of working conditions. The suction pressure can be established in this paper, the BP neural network model calculates the best value of the suction pressure in the load, this value functions as the set value to adjust the operating frequency of the compressor, and the refrigerator reaches the best working condition in each load.

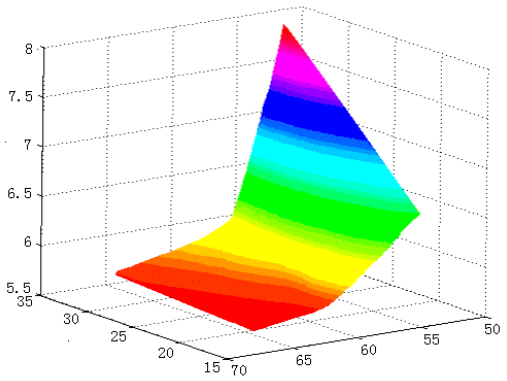

Figure 3 80% load nowadays variable relationship

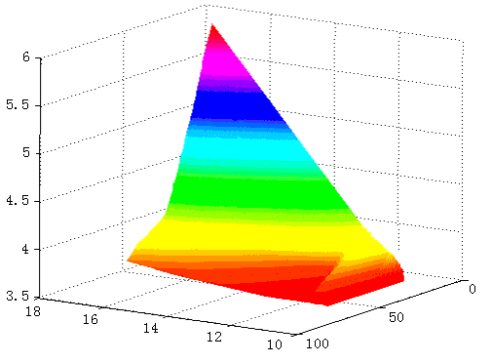

Figure 4 40% load nowadays variable relationship

The following sections gives a typical load of several groups, the BP neural network model to calculate the value of the optimal conditions of suction pressure corresponding to the refrigerator temperature of the compressor inlet and compressor outlet refrigerant temperature value.

Inverter multi air conditioning system is the set of some of its load power consumption and indoor air temperature and outdoor air temperature. MIAC-1 system presents as an example now, in turn draw in different indoor set temperature value, the power loss curve of the inverter multi air conditioning system. Figure 4 is the three indoor units with fully open condition, the change of frequency conversion air-conditioning system power. The figure shows, the air conditioning unit operating hours as the outdoor temperature is gradually increased, MIAC-1 unit runs, the power consumption is gradually increasing; 15:00 temperature reached a daily maximum of 32.6 degrees, due to the building envelope thermal inertia of the structure of cooling load delay, the formation of power reaches its maximum at 16:00 lag of one hour.

Noting that the 8:00 to 11:30, when the outdoor temperature is below the indoor set temperature, there is still a certain amount of cooling load. Examine the regional indoor heat settings and found that the set value is too large, the level of heat gain, such as electronic equipment for 32.40W/m2, [7] recommended values 16.15W/m2 more than doubled; In addition, examples Housing envelope insulation is good, the ground adiabatic surface, roof 25mm thick, the thermal conductivity of insulation materials insulation 0.0432W / (m • K), the wall is 100mm brick wall, the thermal conductivity 0.7260.0432W / (m • K), the above factors make a large indoor heat load which were not timely distributed through the building envelope to the outdoor environment, you need air conditioning units to provide part of the cooling capacity to maintain the indoor temperature settings. This situation is similar to the winter large buildings within the district needs cooling.

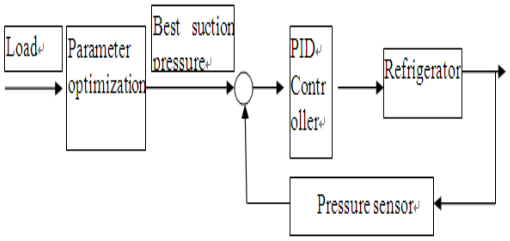

Figure 6 refrigerator optimal control chart

2.3 Cooling system optimization control method

Through the above analysis, the optimal control methods for refrigerator steps are presents as follows: established in a certain load, BP neural network model to calculate the optimal suction pressure value, and get the best conditions for compression machine inlet refrigerant temperature, the compressor outlet refrigerant temperature value, these two values need to meet the requirements of the best working conditions, the best suction pressure value functions as the set point, the PID controller is widely used in engineering control operating frequency of the compressor suction pressure to achieve this setting, keep the refrigerator run in the best conditions in the load.

50% of the load, the rated condition, refrigerator energy consumption 1.876Kw, refrigerator energy consumption, energy saving of it is about 44.8% , 1.035Kw, with this control method.

Table 3 different load conditions

Load（%）	Refrigerator temperature of compressor inlet（℃）	Compressor outlet temperature of the refrigerant（℃）	Suction pressure（Bar）
100	32.4	67.3	8.03
80	31.7	55.4	7.84
70	30.1	46.7	7.64
60	26.6	38.1	7.22
50	23.5	32.3	6.61
40	16.7	26.2	5.91

3. Conclusions

(1) This chapter uses the BP neural network in the analysis of the advantages of the suction pressure as a refrigerator compressor control variables, the mathematical model of the refrigerator suction pressure, according to this model, calculating the different loads under the best conditions corresponding to the value of suction pressure.

(2) Analyzing and verifying the different load chiller performance parameters of the COP and the suction pressure, and the outcome are obtained under different load conditions.

(3) Given the optimal control method for a refrigerator, under different loads based on neural network best suction pressure calculated value and the best conditions, in conditions of optimum working conditions, controlling the operating frequency of the compressor suction pressure values to achieve the best value. The purpose of the refrigerator is to run in optimum working condition, which is guided under the optimal control of the entire HVAC system.

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Dr.He Bingqiang received the Master's degree in mechanical engineering from Guangdong University of Technology, in 2004. He received the Ph.D. degree in Vehicle engineering from the South China University of Technology, in 2010. Currently, he is a professor at Guangdong Jidian Polytechnic, Guangdong. His research interests include FACTS and Power System Dynamics.

Mis. Liao Chunling received the Master's degree in software engineering from SUN YAT-SEN UNIVERSITY, in 2010. He is a professor at Guangdong Jidian Polytechnic, Guangdong. His research interests include computer.